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ABSTRACT

To better determine the cognitive abilities needed for computer programming, a study was done using 41 junior and senior level college students majoring in social and behavioral sciences at a Los Angeles area university. The subjects were first tested to determine their cognitive abilities with regard to spatial ability, field dependence/independence, general reasoning or non-verbal intellect, analytic versus holistic processing, and math skills. These results were then compared with the results of a test of the subjects' computer programming skills after 10 weeks of computer instruction. Results of this comparison show a positive correlation between computer programming and several cognitive abilities. A comparison of the results of this study with those of a similar study done by Shaha (1983) using graduate students indicates that this study verifies Shaha's findings with one major exception--the order of regression coefficients for overall programming ability. A table of regression coefficients and a bibliography are attached. (Author/JB)

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Cognitive Abilities and Computer Programming

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Abstract

To better determine cognitive abilities needed for computer programming, a study was done using junior and senior level college students majoring in social and behavioral sciences. The subjects were first tested to determine their cognitive abilities. These results were then compared with the results of a test concerning computer programming skills, following ten weeks of computer instruction. Results of this comparison show a positive correlation between computer programming and several cognitive abilities. Implications of the study are discussed.

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Introduction

As the educational value of the computer has become apparent, there has developed a feeling that we, as educators, need to better understand what effect the computer has upon the user, and what cognitive processes are involved in computer programming. Studies done by Webb (1984) and by Shaha (1983) are the beginning cornerstones in the search for understanding concerning the interaction of the mind and the computer. This study seeks to add to the accumulating information by further defining what cognitive processes are involved in programming. Unlike Shaha's study which used graduate students, this study used undergraduate college students. It was felt that the resulting information would be more generalizable to future studies.

Method

The subjects for the study consisted of 41 junior and senior level college students majoring in social and behavioral sciences at a Los Angeles area university. The subjects were enrolled in an introductory computer class. Prior to the instruction, the students completed four hours of testing in cognitive measures, including:

Spatial Ability: Paper Folding Test (ETS, 1962), Surface Development Test (ETS, 1962), and the Form Board Test (ETS, 1962).

Field Dependence/Independence: Hidden Figures Test (ETS, 1962).

General Reasoning or Non-verbal Intellect: An abbreviated form of the Raven's Progressive Matrices (Raven, 1958).

Analytic versus Holistic Processing: Gestalt Completion Test (ETS, 1962).

Math Skills: A test devised that consisted of two sections, a math reasoning section that consisted mainly of word problems, and a math computation section consisting of mechanically computational items.

Following the pretest, the students received 10 weeks of instruction in the computer language BASIC. The class met one night per week for 3 hours. The course consisted of instruction in operating commands, boolean operators, looping routines, branching, stringing and numeric variables, and mathematical expressions. A posttest was administered to determine the ability of the students in program generation and debugging, and to test their knowledge of BASIC commands and syntax.

Results

Analysis of the pretest and the posttest was done using a stepwise multiple regression process. The posttest was divided into four subareas. Separate stepwise regressions were performed with scores from each subarea and the total score as criterion variables, and all cognitive tasks as predictors. Results for all significant regression coefficients ($p<.05$) are shown in Table 1.

Insert Table 1 here

Discussion

As was stated at the beginning of this article, this study was done for two purposes. These purposes were to determine what cognitive processes seem to be involved in computer programming,

and to check the results of a similar study done by Shaha (1983), using graduate students, to see if any results could be generalized. The results of the study seem to have accomplished these purposes. For example, the results of this study seem to verify what Shaha found, with one major exception. The exception was the order of the regression coefficients for overall programming ability. Shaha found that holistic reasoning had a higher correlation with programming ability than did math reasoning, which is exactly opposite of this study's results. This seems to verify the idea that graduate students tend not to represent the "average" person, as far as cognitive processes are concerned. This would also seem to indicate that while math reasoning is important to learning computer programming, it is not the only factor involved in succesful learning.

The rest of the results of the study seem to indicate that computer programming is the result of many cognitive processes, and not just mathematical reasoning, though this is not intuitively obvious. The results also tend to indicate that, depending on what is being done, totally different processes are at work. For example, for programming ability it is important to be able to view the program as a whole, and not just a collection of separate statements. The opposite is true though, if you are concerned with syntax, as is indicated by the high correlation between field independence and syntax in Table 1.

The results of the study are interesting in another area. While it is generally assumed that there is a relationship between general and mathematical reasoning, the results of the

analysis shows a sign difference in the regression coefficients for syntax. The reason for this negative correlation is still not well understood.

Another interesting aspect of the analysis is that while mathematical reasoning is highly correlated with overall programming ability, it is relatively insignificant for the more fundamental aspects of programming. This tends to indicate that math reasoning is more closely related to primary abilities than the other cognitive processes tested. It may also indicate that spatial ability, field independence, general reasoning, and holistic reasoning form a foundation for mathematical reasoning.

It is apparent that while this study did accomplish what it set out to do, it is also apparent that it created many unanswered questions. It is hoped that the questions asked in future can now be directed in areas that will lead to new understanding in the field of cognitive processes.

TABLE 1

Regression Coefficients

	Syntax	Debugging	Commands	Program Generation	Total
Math Reasoning	.5108				.5875
Math Computation					
Form Board		.3017			
Surface Development					
Paper Folding			-.6017		
Raven's	-.5600	.5805			
Hidden Figures	.8076				
Gestalt Completion				.6363	.4065

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